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Improved Modeling of Drop Vaporization and Combustion in Diesel Sprays

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12 a. DISTRIBUTION / AVAILABILITY STATEMENT
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13. ABSTRACT (Maximum 200 words)

The objective of the research work is to identify limitations of simplified droplet vaporization and combustion models in Diesel sprays and to improve them. Detailed numerical studies of isolated drops, isolated droplet vaporization within the framework of multidimensional model computations, and multidimensional spray computations have been carried out. During the course of the year, the methods adopted for property estimates, variable density effects, multicomponent effects, and ambient gas effects on droplet vaporization were studied. The effect of the numerical resolution on single drop predictions were also studied. The overall conclusion of the work during the course of the year was that under warm Diesel operating conditions, the vaporization rate in diesel sprays is mixing-controlled and, hence, the detailed effects of the vaporization model are not important. Under cold-start conditions it is more important to account for detailed droplet vaporization phenomena.

14. SUBJECT TERMS
Drops; Diesel sprays; Diesel cold start

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Enclosure 1

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1. List of manuscripts
   (i) S. Post and J. Abraham, "An Evaluation of a Current Model for Collisions and Coalescence in Diesel Sprays in Light of Recent Experimental Findings," paper presented at the 8th International Conference on Liquid Atomization and Spray Systems, Pasadena, CA, July 2000.
   (ii) V. Iyer, S. Post and J. Abraham, "Is the Liquid Penetration in Diesel Sprays Mixing Controlled?" paper presented at the 28th Intl. Symposium on Combustion, Edinburgh, UK, August 2000.
   (iii) S. Post and J. Abraham, "A Computational Study of the Processes that Affect the Steady Liquid Penetration in Full-Cone Diesel Sprays," accepted for publication in Combust. Sci. Tech., December 2000.
   (iv) S. Post and J. Abraham, "Modeling the Outcome of Drop-Drop Collisions in Diesel Sprays," submitted to Intl. J. Multiphase Flow, October 2000.
2. Scientific personnel
   Scott L. Post, a graduate research assistant, pursuing his Ph.D. and the P.I., John Abraham, have been supported on this grant.
3. Report of inventions – none
4. Scientific progress and accomplishments
   It has been shown in experimental work carried out at Sandia National Laboratories by D.L. Siebers and by modeling work carried out in the P.I.'s group that, under warm operating conditions, the vaporization in Diesel sprays is mixing-controlled and the vaporization time is not relevant. However, under cold-start conditions, the vaporization time becomes comparable to the mixing time. In this case, it is important to estimate the vaporization time with adequate accuracy. In the work carried out here, it has been shown that the accurate estimate of properties of the liquid and vapor phases, the composition of the fuel, variable density effects of the liquid phase, drop-drop interactions and numerical accuracy are all important parameters in determining the vaporization rate. The dependence of the latent heat of vaporization, partial pressure of the vapor phase and liquid density on temperature has to be included to get results with adequate accuracy. The estimate of the properties at the liquid drop surface by employing the 2/3 rule gives adequate results provided the droplet is isolated in an infinite environment. Results vary depending on the number density of the drops in the spray and the numerical resolution employed. Vaporization rates are significantly affected by the composition of the fuel. In this respect, if a single component is employed to represent the fuel, the adequate specification of the average properties is important. Results of vaporization rates can vary by as much as 50% depending on how these properties are specified.

   While results from isolated single droplet studies are somewhat tractable to evaluate, those in sprays are affected by several additional parameters. The vaporization rate has D^2 dependence on the droplet diameters, D. In a spray, the droplet diameter depends on the injected drop size and collisions and coalescence. The collisions and coalescence model is extremely sensitive to numerical resolution. In work carried out as part of this project, an improved collision and coalescence model has been proposed that gives improved results. The revised model shows that collisions and coalescence may be less important in Diesel sprays than previously thought.
5. Technology Transfer
   There have been regular interactions with Diesel manufacturers as part of this work. These include Cummins Engine Company, Detroit Diesel Corporation and Navistar Corporation. There have been interactions with researchers at the University of Wisconsin and Princeton University.

Enclosure 2

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Sincerely,

John Abraham
Associate Professor